The effects of wheel imbalance and runout in fixed-abrasive grinding

K L Blaedel and J S Taylor

Lawrence Livermore National Laboratory
P O Box 808, L-537
Livermore, CA 94551
(510) 422-0290 voice
(510) 423-1460 fax

The purpose of balancing a grinding wheel is to minimize force perturbations generated by the spindle axis that would degrade workpiece surface quality. Surface degradation might be manifested by either increased roughness and subsurface damage due to increases in instantaneous grinding forces, as well as, figure errors due to motion errors in the axis-of-rotation. Another source of force disturbance arises from the runout of the grinding wheel surface acting against the workpiece, which is often addressed independently by truing the wheel prior to grinding. The presence of runout causes a temporary increase in depth of cut, which leads to higher grinding forces. This paper explores the roles played by imbalance and runout as sources of the total synchronous force vector imposed on the workpiece and the machine tool.

The effect of imbalance and runout on surface quality can arise directly from the varying normal force of grinding, as well as, the varying tangential force between the workpiece and the wheel. Using elementary dynamics equations to describe the structure and the wheel, we show how these perturbing forces can cause the stable or unstable excitation of the machine tool structure depending on whether the operation of the spindle is below its resonance where bearing stiffness is the major moderating effect, or above its resonance where rotor inertia becomes dominant. This also leads to a criterion for determining whether wheel runout will grow or be self-correcting.

We begin with the requirements for workpiece surface quality, and, using a wear model for the material removal process, translate surface quality into an allowable level of perturbation in the grinding force. This translates into allowable levels for imbalance and runout in order to limit the magnitude of the force variations.

This analysis is extended to incorporate a structural loop and workpiece spindle for an existing grinding platform. This extended analysis shows how the total force perturbation arising from imbalance and runout of the workpiece spindle, in combination with the grinding spindle, affects the quality of the workpiece surface.

The functional requirements for roughness and form errors lead to specification for balance and runout errors. Practical limitations to the quality of balancing are examined, such as, balancing in the presence of residual runout of the wheel, of asynchronous spindle error motion, or the presence of a fluid. Also, consideration is given as to whether acceleration, displacement, or grinding force should be used as the sensed quantity upon which to minimize the total force perturbation.

---

* This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.